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NASA TECH BRIEF

A Radiometer–Pyrometer

A radiometer–pyrometer was developed for the measurement of the spectral absorption, emission, and temperature of gases. The major problems involved in spectroradiometric measurements and the methods of overcoming them in this instrument are as follows:

(1) Nonuniform spectral sensitivity. The sensitivity of most radiation detectors varies with time, temperature, fatigue, and other factors, so that the error of absolute flux measurements is generally greater than 1 percent. By providing an internal reference lamp that has greater long term stability than the detector and alternately measuring the reference and the sample radiation with the same detector, accuracy approaching the reference can be obtained. This principle has long been used in optical pyrometers, and successfully applied to automatic pyrometers, radiometers, and other commercial instruments.

(2) Nonlinearity. When the internal reference lamp is operated at a fixed temperature, a ratio of the sample radiation to the reference can be obtained. Large ratios, however, require either a detector with linear response or a calibrated nonlinear detector. Also, large ratios may be subject to error in the smaller flux measurement caused by the addition of stray radiation from the larger flux. By attenuating the internal reference source with an aperture, an approximate match to the sample radiation within a 10:1 ratio can be made. The detector linearity requirement is thereby lessened, and the linearity errors are minimized. This method is used in the present instrument, with 4 beam attenuators giving a reference-lamp-flux range of 10^6. In addition, the reference-lamp current is continuously variable and gives an additional flux range of 10^2.

(3) Poor absolute accuracy. By using the internal reference lamp as a transfer device, the ratio of intensity of an external sample source to intensity of an external standard source becomes the actual measurement. Available external standard spectral sources are commercial blackbody cavities at 1000°C and a calibrated tungsten ribbon lamp.

(4) Wide range of intensities. A limitation of the thermal radiator as an external standard source is the wide variation of intensity with wavelength in accordance with the Planck spectral distribution. In the ultraviolet, the intensity of a 2860°K blackbody changes greatly for even a slight change of wavelength so that, for example, from a peak intensity at 1 micron it is reduced by a factor of 10^5 at 0.2 micron. Thus, over a wide range of wavelengths, an incandescent lamp is far from an ideal spectrally independent source. This fact tends to complicate its use as a reference by which a measurement is divided. The complication is minimized in applications such as automatic pyrometers, where the utilized wavelength range of the lamp is limited or fixed. The wide range of intensity level is covered in this instrument with detector apertures giving an attenuation range of 10^3 and amplifier gain that is variable over a range of 10^3.

(5) Wide range of wavelengths. No one detector is best at all wavelengths. The detection improves as the range of detector response is confined to the short wavelengths, where a photon has greater energy and ambient radiation is small. Thus, the photoemissive detector limited to the ultraviolet and visible spectrum is superior to a photoconductor, which responds to wavelengths extending from the ultraviolet through the near infrared. Such a photoconductor, in turn, is superior to the thermal detector, which responds to

(continued overleaf)

the far infrared as well. A choice of three detectors is provided in this instrument to obtain the best detection at any wavelength.

Note:

Details concerning the design and operation of this instrument are given in NASA TN D-2405, "Radiometer–Pyrometer for Analysis of Gaseous Combustion Processes", by Donald R. Buchele, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151. Inquiries may also be directed to:

Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
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No patent action is contemplated by NASA.

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